IDAHO TRANSPORTATION DEPT. CENTRAL MATERIALS

Life Cycle Cost Analysis

Spreadsheet User's Guide

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Chapter

1

Introduction

The purpose of a life cycle cost analysis (LCCA) is to assist the Engineer in the decision making process as to which strategy is appropriate for the project in question. The purpose of the analysis is to identify which strategy can be reasonably assumed to be the most economical given known or assumed conditions at the time of the initial project reconnaissance. Factors which play into this decision include traffic, design requirements for various alternatives, construction traffic, construction funding amounts, desired project life, to name a few. Hence, the most economical alternative is usually, but not always the most viable. For clarification purposes, in this manual, when the term "Life Cycle Cost Analysis" is capitalized, reference is made to ITD procedures for such an analysis as per the ITD Materials Manual. If the term is not capitalized, reference is made to the concept of "life cycle cost analysis" in general.

The scope of certain projects is such that only one alternative is considered reasonable. An example of this would be a small bridge requiring a minor realignment which uses the existing bridge to carry traffic until construction is completed. In such a case, analysis of the roadway as a reconstruction (the costs of which can be assumed to be similar to those of original construction) is the only option accommodated by the Life Cycle Cost Analysis program. Hence the only two viable alternatives are flexible and rigid reconstruction. Generally, it is preferable to maintain a consistent roadway section. Assuming the existing roadway consists of flexible pavement, it may be undesirable to construct a short segment of rigid pavement, even if rigid pavement can be shown to be more economical. In such a case, a Life Cycle Cost Analysis may be unnecessary and superfluous. Consulting Materials Engineers should discuss elimination of the Life Cycle Cost Analysis with the District Materials Engineer if such elimination is considered appropriate. Documentation of the reasons for elimination of the Life Cycle Cost Analysis should be included in the Phase I or Phase II report as appropriate.

The purpose of this guide is to provide guidance in the identification of a "most economical alternative" after evaluation of various construction / maintenance strategies using the ITD Life Cycle Cost Analysis spreadsheet program. The program requires a copy of Microsoft Excel 5.0 or 7.0 residing on the machine to be used to run the program. The Excel features of the program must be saved and maintained in Version 5.0. The program can be run in Excel 7.0; however, saving the program in Microsoft Excel 7.0 will cause the program to degrade. Also, the sheets are "protected", and "unprotect" macro must be run before saving. The program also includes additional "bells and whistles" programmed in with **Visual Basic**. The purpose behind adding the Visual Basic additions is simply to allow faster scrolling through the program, delineate which sheets are used in calculations for each option, and to show a typical section for the option being analyzed.

The program updates automatically as data is entered. Files can be saved and rerun with data changes later; however, it must be ensured that the "unprotect" macro is run prior to saving.

Life Cycle Cost Analysis as performed in the development of Idaho Transportation Department projects differs somewhat from a traditional engineering economic analysis. Costs can be calculated, but benefits to the traveling public and the actual dollar value of a roadway are not easily quantified. Hence the following disclaimer statement.

Disclaimer

All information provided within the Life Cycle Cost Analysis spreadsheet is conceptual and is intended for use in preparing preliminary estimates for comparison purposes only. Use of any of the values or recommendations associated with the Life Cycle Cost Analysis spreadsheet for any other purpose is at the user's risk. Additional investigations and analyses are required to verify the data presented.

Chapter

2

OPENING THE PROGRAM

Upon executing the command to open the program, a dialog box will appear stating that the program contains macros. The macros must be enabled in order for the program to run.

When the program first opens, it scrolls through all of the sheets to clear out all inappropriate information and re-protect all sheets. Unfortunately, if the program being opened consists of a previously saved version, this methodology of clearing out any previously saved information will cause the program to malfunction when the new analysis is run. After the program is finished scrolling through the sheets, it will return to the Title Page.

The Title Page contains a brief explanation of the functioning of each sheet with respect to the alternative being examined and a warning concerning replacing values shown in the spreadsheet / deleting cell formulas.

The user should then click on the "Next Page" button to open the Introduction page. This is recommended as this step enables the Visual Basic macros in the program to execute properly.

Chapter

3

Introduction Page

The ITD Life Cycle Cost Analysis program currently residing on the Central Materials homepage lists six alternative strategies. These are shown on the Introduction Page:

1) Flexible Reconstruction

2) Rigid Reconstruction

3) Widen and Overlay

4) Inlay / Overlay

5) In Place Recycle

6) CRABS Reconstruction

These are the alternatives which can be compared using the program. The program evaluates each alternate based on a 36 year timeline.

A straight overlay can be compared using the Widen and Overlay option and assuming zero widening. Tentative ballast thicknesses for each alternative should be determined in accordance with Section 220.7.5 of the Materials Manual. Confirmation of these thicknesses by FWD analysis is considered advantageous but is not an absolute requirement. Such confirmation is generally felt appropriate for the elimination of future testing required for the Phase II report provided the FWD data can be properly correlated to the characteristics of the underlying soils as determined in initial testing.

Tentative ballast thicknesses for each alternative being considered shall be determined using the methods described in the Materials Manual. These methods have been tailored as necessary to the state of Idaho and exceptions are not considered appropriate.

Each process /alternative has a Dialog box for entering initial data. When the initial data is entered, or any time a change is made, the program fully recalculates the results. The program makes changes very slowly. The Dialog box allows changes to be made to all parameters contained within this box simultaneously. Changes made in the to individual entries in the individual worksheets require the same amount of time, but only one change at a time can be made in the spreadsheet. Project information which is entered into the Dialog box is copied to all of the alternatives and does not need to be reentered unless it is determined that a change is necessary.

Each Alternative has the following "buttons" representing individual worksheets:

Worksheet

Analysis

Time Line

Summary

These buttons will activate a command to show the identified sheet when executed. This is the same command as clicking on a worksheet tab in Excel, except that the command buttons allow faster transferal of the view between sheets. This is a side benefit of the Visual Basic programming which allows for faster selection of worksheets to view. Each sheet also has a print button on this page which represents a command to print the respective sheet. There is also a "print all sheets" command button which sends all sheets for the respective alternate to the printer.

The bottom row on the introduction sheet consists of command buttons as described above for the Salvage Value Chart and Standard Costs sheet.

One comment concerning the Time Line sheet is appropriate here. Generally, projects are designed for a 20 year design life. This is shown in the default data in the program. However, for various reasons, it may be appropriate to design a project for other than a 20 year life. In this case, the appropriate salvage value should be determined from the Salvage Value Chart and incorporated into the calculations for the alternates being considered. Refer to the chapter on the Salvage Value Chart for further information. Designing for other than a 20 year life requires rewriting the timeline, and making assumptions concerning the future maintenance schedule. In such cases, consultants should discuss these assumptions with the District Materials Engineer, and District Materials Engineers should discuss the assumptions with Headquarters Materials. Designing for other than a 20 year life is not generally recommended. An exception to this is rigid pavement, in which case, a 40 year design is generally recommended. See the chapter on the Rigid Pavement alternate for further information. Additional alternates for 8 year designs are anticipated in future versions of the program.

Chapter

4

Flexible Pavement

FLEXIBLE PAVEMENT WORKSHEET

FAR RIGHT DIALOG BOXES

The far right column in the Flexible worksheet contains 4 command boxes. These and their functions are:

Introduction: Scrolls back to the Introduction sheet.

Toggle Metric: The data for a Life Cycle cost Analysis can be entered in either metric or English units. This command converts metric values and units to the English system and vice versa.

Print Page: Prints the active sheet.

Dialog box: Opens the Dialog box discussed above.

TOP ROW

The top row of information identifies the worksheet/alternative being analyzed and the project by name, project number, and key number. The project information can be entered at this location or from the Dialog box discussed above.

LEFT-HAND COLUMN

The left-hand column in the flexible pavement worksheet identifies typical section and roadway section data to be incorporated into the flexible reconstruction alternative. Thicknesses for various items are entered into the "Depth" column. Particular items which are not being considered / used should be left blank or a zero depth value entered.

Following is a list of the items which may be used in the flexible reconstruction alternate with a short explanation:

Plant Mix with high polymer: Enter thickness for rubberized, polymerized, or Performance Graded (PG) asphalt plantmix pavement layer.

Plantmix with low polymer: Enter thickness for asphalt plantmix layer using traditional asphalt grades or PG asphalts for which the sum of the two grade designations is less than 90 (i.e. PG 58-28).

Asphalt Treated Permeable Base: For use as a drainage layer on Granular Subbase or Granular Borrow. A plantmix leveling course is required for use with this item to fill in the surface voids and provide a smooth paving surface. The leveling course should not be included in the Granular Equivalent thickness of the section.

Aggregate Base: Crushed aggregate base with a ½" or ¾" maximum gradation.

Rock Cap: For use when pavement subsurface drainage is anticipated to be a problem as determined by test hole data or condition of the existing roadway. A plantmix levelling course is required for use with this item to fill in the surface voids and provide a smooth paving surface. The leveling course should not be included in the Granular Equivalent thickness of the section.

Granular Subbase: Subbase material with a 4" maximum size gradation; standard item.

Granular Borrow: Not currently recommended as a pavement section item unless otherwise approved. Current specifications for this material do not provide controls necessary to ensure a quality product.

Rotomill: Enter a minimum value of 1.8" or 45mm as this is used in calculating future rehabilitation costs. A higher value may be entered if considered appropriate.

The next set of data to be entered in the left-hand column consists of geometric data describing the project.

Project Length

The program calculates costs as follows:

Metric:

For project length = 0 to 1000 m: Total Cost

For project length greater than 1000 m: Cost/ km

<u>English:</u>

For project length = 0 to 5280 ft: Total Cost

For project length = greater than 1 mile: Cost / mile

For standardization and comparison purposes, project costs are generally calculated on a per mile or per kilometer basis even when the total project length is less than 1 kilometer or 1 mile. Hence, either 1000 m or 5280 ft. is entered for this value.

Travel Lane Width

At this point it is important to note that the Life Cycle Cost Analysis program is a materials based program. The program is not intended for actual project design or traffic design. The program was developed for project life cycle calculations using a two way, two lane roadway as a template. Hence it is not necessary for the program to discriminate traffic lanes for every type of roadway configuration.

The value entered for travel lane width is the total width of the traveled way in the roadway. For example, for a roadway consisting of two 12' lanes on the left, one 12' lane on the right, and a 14' center turn lane, and 5' shoulders, the value entered here is 50'. Shoulder widths are not included.

Surface Width – Left/Right Side

The value entered here represents the surface distance from the centerline of the roadway to the beginning of the pavement shoulder slope. Generally, the same value, one-half of the total surface width, is entered for both the left and right surface widths. Refer to the subsection on the typical section for further information.

Additional Borrow

The value entered here consists of an estimated total price per mile or kilometer for additional borrow which may be associated with this alternate, but not with another alternate. For example, a reconstruction alternate for a project may include additional fill for flattening a sag vertical curve. For the same project, a rehabilitation alternate such as an inlay/overlay would not include this additional borrow. Thus the additional cost for the fill included with reconstruction but not inlay/overlay can be accommodated in the Life Cycle Cost Analysis.

Traffic Crossovers

The value entered here consists of an estimated total price per mile or kilometer for traffic crossovers which may be associated with this alternate, but not with another alternate. Essentially, this represents a similar situation to that described above in the subsection on Additional Borrow and is accommodated in the LCCA program in the same manner.

Longitudinal Cracks

The value entered here is used in calculating costs incurred in sealing joints and cracks in future maintenance operations. The anticipated number of cold joints for a flexible reconstruction is considered appropriate. It is noted that ITD Standard Specifications allow only one longitudinal cold joint per pavement lift.

Transverse Cracks

As transverse cracking can be anticipated to develop regardless of which flexible pavement option is being evaluated, an estimate of 100 cracks/km is generally used. As with the data for Longitudinal Cracks, this value is used to estimate future crack sealing costs (for the purpose of Life Cycle Cost Analysis).

Foreslope Angle – Left and Right

Enter the design slope(s) for the roadway section. This information is used in calculating quantities and drawing the typical section.

Additional Excavation

The value entered here consists of an estimated depth of excavation which may be associated with this alternate. The program assumes the depth of excavation entered here is for full length of the section being evaluated. For Flexible Reconstruction, excavation is estimated full width of the roadway including shoulders.

A toggle / "check" switch must be activated to incorporate this cost into the analysis.

Subgrade Separation Fabric Layer

The value here consists of an estimated (calculated) width of subgrade separation fabric which may be associated with this alternate, but not with another alternate. The intent is that this fabric is associated with an identified drainage problem. The quantity is calculated based on the width of the roadway at the bottom of the subbase layer. The intent is for this to represent a similar situation to that described above in the subsection on Additional Borrow and is accommodated in the LCCA program in the same manner. However, the program currently calculates this cost as if it were a pavement membrane to be added as a component of the future maintenance program. For these reasons, it is generally recommended that "Subgrade Separation Fabric Layer" not be incorporated into the alternate "model". The user may consider it appropriate to incorporate this information into the LCCA; i.e. it is anticipated that a pavement membrane will be used in the future. If so, and the user elects to incorporate this cost into the LCCA, such decision should be documented in the LCCA report. This error will be corrected in a future version of the program.

A toggle / "check" switch must be activated to incorporate this cost into the analysis.

Inclusion of a Subgrade Separation Fabric has not generally been found to significantly affect the outcome of a Life Cycle Cost Analysis.

Standard Remaining Life

The worksheet contains a switch which toggles between a 12 and 24 year remaining life. This switch has been placed in the sheet in anticipation of future development of the program for the purpose of considering such options. Currently the switch does not affect the program with the exception of implying the design life of the project.

Haul

The sheet allows the user to enter an anticipated haul distance for various items. In reference to Flexible Reconstruction and other appropriate options, the distance to the nearest anticipated materials source for plantmix and other materials is generally a reasonable value to enter here. For Rigid Reconstruction, a distance to the nearest concrete batch plant is generally considered an appropriate haul distance for concrete.

Width

The program calculates appropriate widths for the bottom of the layer concerned based on the input described above. It is not normally necessary to enter new values in this column. If any new values are entered, the cell formulas will be overridden. Hence, entering new width values is not recommended unless extenuating circumstances dictate.

Weight

The program reads a unit weight from the Standard Costs sheet for all layers in which a thickness is entered. As with the Width information, new data should not be entered unless extenuating circumstances exist as the cell formulas will be lost. As the purpose of the Life Cycle cost spreadsheet is for preliminary cost comparisons only the slight differences in the estimated unit weights and any anticipated actual unit weights are generally considered negligible.

Cost

As with unit weights, unit costs are read from the standard costs sheet. The same comments with respect to entering new values apply.

Color

Also shown next to the Cost column is a color key referring to the typical drawing. The key is intended for use in identifying color coded pavement section layers and relating them to the Life Cycle Cost Analysis.

Typical Section

As discussed above, the program is based on a two way, two lane roadway as a template. The program also draws a typical section based on input data as discussed below. The calculations / drawing of the typical section do not affect the cost calculations of the program. However, when the program does not draw the typical section correctly (i.e. symmetrically, with properly shown depths and slopes), this is an indication that the input data may not be correct. In drawing the typical section, the program assumes the roadway centerline is in the center of the typical section. Therefore, it is generally advisable to assume a symmetrical roadway for the purposes of the Life Cycle Cost Analysis program. This assumption eliminates one potential source of error.

When a value is changed in the dialog box or the worksheet, it may be necessary to click on the typical section in order to execute the command to redraw the typical. The width and scale command boxes adjust the size of the drawing to assist the program in the automated drawing of the typical section. This is their only function; as with the drawing itself, these command boxes do not affect the program quantity or cost calculations.

Width and Scale

The sheet includes toggle switches which are used to control the width and scale of the drawing. These are intended to be used to size the drawing to fit in the space allotted. These command switches do not affect the calculated values of the program. The typical section does not represent an actual scale drawing.

FLEXIBLE PAVEMENT ANALYSIS SHEET

This is a calculation sheet for determining the costs for various items considering widths, thicknesses, etc. Values are read from the worksheet and the Standard Costs sheet and costs are calculated as appropriate. The calculated values are also read by the other sheets as appropriate. The costs shown with borders represent results which are used in the following Flexible Pavement Reconstruction Timeline sheet. The analysis sheet also contains the Introduction, Toggle Metric, Print Page, and Dialog Box command icons as previously described.

This is the sheet on which the "meat" of the work is done for the Life Cycle Cost Analysis sheet. It is not generally felt to be necessary to include this sheet with LCCA reports as the relevant information is contained on other sheets in a more readable format. However, many report authors do include this sheet in the Appendix with the other sheets for reference purposes.

The Life Cycle Cost spreadsheet was originally written in Quattro Pro format. There may also be Lotus versions in existence. Since that time, it has been transferred to a previous version of Microsoft Excel, and updated to the current version. Obviously, it will be necessary to continue to update the program as new spreadsheet software versions/programs become the standard for use. Every time the program is updated or converted to a different format, there is a risk that the some steps of program (i.e. some cell assignments / calculations) may not be converted or updated correctly. This continual updating has therefore had an effect on the functioning of the Life Cycle Cost spreadsheet. The most noticeable effect has been that certain cell assignments in the Analysis sheets are not always updated correctly. Also, other sheets which read values from the analysis sheet may contain incorrect cell assignments. Microsoft Excel coding includes formatting procedures to preclude this and an attempt has been made to modify the problem cells/commands to prevent this from happening in the future. However, the program did not originally include such coding throughout, as it was not originally intended for the widespread use which it is seeing. These incorrect cell assignments have been corrected as they have been found, but it is not absolutely certain that all of them have been found and corrected. Therefore, it is recommended that the Analysis sheet as well as all other sheets be checked to ensure that the appropriate values are being shown.

Any errors which are found should be corrected prior to use of the results of the LCCA program in decision making with respect to a project. Please contact ITD Central Materials with notification of the program error so it can be corrected. As an informational note, the previous versions of the program do not contain the Visual Basic upgrades.

FLEXIBLE RECONSTRUCTION TIMELINE

This sheet represents an attempt to identify total costs associated with a project based on a 36 year timeline. These costs include initial project cost, an idealized maintenance schedule, and a major rehabilitation at 24 years. This sheet also includes the Introduction, Toggle Metric, Print Page, and Dialog Box command icons as previously described.

As future maintenance costs for a project cannot be known as an absolute certainty, an idealized maintenance schedule is assumed. In the real world of pavement maintenance, this aggressive schedule of applications may not be possible considering immediate funding issues at the time in question and annual agency maintenance budgets. Also, if the roadway in question carries a low amount of traffic, such a maintenance schedule may not be needed. However, the cost effectiveness of aggressive preventative maintenance with respect to long term / life cycle costs has been firmly established. A consistent standard is needed for comparison of alternatives. Therefore, rather than attempt to project maintenance costs for each individual project for all alternatives being considered, an idealized maintenance schedule is assumed in the program.

Year

This column identifies each year of the 36 year timeline.

Work

This column identifies the type of work to be done at a given year given the idealized maintenance schedule assumed in the Life Cycle Cost Analysis.

Cost

This column lists the costs for the work at the assigned year as calculated in the Analysis sheet. The values are considered "current", even though they are assigned at future years. Inflation is not accounted for as the overall inflation rate will be the same regardless of which alternate is selected. This will be dealt with further in the following paragraphs.

Initial Cost can be a criteria for comparison of alternatives when project funding is an issue. In such cases, engineering judgement is required.

Costs are rounded to the nearest $100 as it is felt that any more precision than this is irrelevant.

A "Total Cost" is shown at the bottom of this column. This value can be considered an estimate of the anticipated total expenditures for the project over a 36 year life cycle relative to the other alternatives being considered. A comparison of the Total Costs for various alternatives is one criteria by which alternatives can be compared. However, when doing so, the Equivalent Uniform Annual Cost (EUAC) discussed below should also be taken into consideration and the use of engineering judgement is required. Comparison of alternatives by total costs alone does not account for the effect of pavement deterioration.

The reader will note that the Salvage Value at 36 years is assumed to be $0. One of the assumptions of the program is that the project will be thoroughly deteriorated at the end of 36 years and rehabilitation will not be feasible. While this may not be the case in reality, there is also no justification for assuming that a theoretical section of roadway will not be completely deteriorated. The only Salvage Value which can be reasonably assumed to exist after 36 years is felt to be that of any raw materials which could be theoretically be recycled into the subbase layer. Any such value is considered negligible at this time. With the increasing scarcity of materials sources, this assumption may be reevaluated in the future, but is considered valid at this time. Also, at a time 36 years in the future, it is entirely feasible that the existing type of pavement surface (i.e. flexible or rigid), base, and subbase materials may become uneconomical and require removal. For these reasons, and reasons of consistency previously discussed, a Salvage Value of $0 at 36 years is assumed.

Present Worth Factor

This column lists Present Worth Factors (P/F) for the identified year in the life of the project. The Present Worth Factors are taken from standard economics tables. The cost described above is converted back to a present worth value at an "interest rate" of 4%. As previously stated, the LCCA spreadsheet does not account for growth of the economy or inflation. Both of these will be the same regardless of which alternative is chosen or the maintenance strategy in question. For the purposes of Life Cycle Cost Analysis, the "interest rate" which is of concern is the rate of deterioration of the roadway. The deterioration rate which has been selected for use for this purpose is 4%.

The "Total Cost" discussed above is not calculated using these factors. The use of these factors is discussed below.

Capital Recovery Factor

As with the Present Worth Factors, the Capital Recovery Factor (A/P) used in the Life Cycle Cost Analysis is the standard factor for an interest / deterioration rate of 4% as discussed above and a total project life of 36 years. As inflation and economic growth are not considered, there is no need to modify this calculation otherwise.

Equivalent Uniform Annual Cost (EUAC)

The EUAC for each application is calculated in the spreadsheet by multiplying the Cost * PWF*EUAC. The costs for all applications are summed to give an EUAC for the 36 year project life. This value takes into account the 4% pavement deterioration rate, and provides a better measure of cost effectiveness than the Cost data.

Total Net Present Worth

The Total Net Present Worth is the total EUAC with the Capital Recovery Factor taken out. In other words, it is a total cost estimate of the project in present dollars considering pavement deterioration and relative to the other alternatives being considered. Comparison of alternatives using Total Net Present Worth will yield the same results as comparison using the EUAC values.

FLEXIBLE RECONSTRUCTION SUMMARY

This sheet summarizes the calculations of the previously described sheets with respect to Flexible Pavement Reconstruction. As with the other sheets, a heading is shown which includes the date, project information, and designation of the alternative being considered. Following this is a short one sentence description of the initial construction included in the alternate including widths, thicknesses, and slopes.

The summary shows costs per kilometer (metric) or per mile (English). Summarized are costs for initial construction, subsequent sealing, 12 year rehab, and 24 year rehab. Emphasis is given to various items distinguishing this alternate from others. Following this information is listed the Total 36 year cost, EUAC, and Net Present Worth from the Timeline sheet. The Summary sheet provides simple concise identification of the characteristics of the alternate.

Chapter 5

Rigid Pavement

RIGID PAVEMENT WORKSHEET

A positive drainage design as per the Materials Manual is generally recommended for rigid pavement. Elimination of the requirements for a positive drainage design / system should be justified in the Phase I Materials Report / Geologic Reconnaissance.

Far Right Dialog Boxes

The far right column in the Rigid worksheet contains the 4 command boxes as in the Flexible worksheet; Introduction, Toggle Metric, Print Page, & Dialog box. These function in the same manner as in the Flexible worksheet.

Top Row

As with the Flexible worksheet, the top row of information identifies the worksheet/alternative being analyzed and the project by name, project number, and key number. The project information can be entered at this location or from the Dialog box.

Left-Hand Column

The left-hand column in the rigid pavement worksheet identifies typical section and roadway section data to be incorporated into the flexible reconstruction alternative. Thicknesses for various items are entered into the "Depth" column. Particular items which are not being considered / used should be left blank or a zero depth value entered.

Following is a list of the items that may be used in a rigid pavement design with a short explanation:

PCC Surface: Portland Cement Concrete surface; enter the thickness as determined from the design method described in the Materials Manual.

Asphalt Treated Base: Enter the thickness as determined in the design. Asphalt Treated Base (ATB) is generally not recommended for use with rigid pavements. Subsurface Drainage is generally an issue in rigid pavements and ATB is not generally considered conducive to drainage. If project characteristics dictate that ATB is appropriate, justification for its use should be documented in the LCCA report.

Asphalt Treated Permeable Base: Asphalt Treated Permeable Base (ATPB) is intended to be more conducive to drainage than ATB. It is intended for use as a drainage layer on Granular Subbase or Granular Borrow. For example, it may be appropriate to use ATPB in a case where positive subsurface drainage is needed, but Rock Cap (discussed below) is unavailable. An Asphalt Treated Plantmix Leveling Course (ATPLC) is generally required for use with this item, depending on the gradation, to fill in the surface voids and provide a smooth paving surface. The leveling course should not be included in the Granular Equivalent thickness of the section. If project characteristics dictate that ATPB is appropriate, justification for its use should be documented in the LCCA report.

"ATPB Leveling Course": The title for this material has been changed since the most recent version of this program. The correct title for this material is **Asphalt Treated Plantmix Leveling Course (ATPLC)**. The purpose of an ATPLC is to fill in the voids on the surface of a granular base such as Rock Cap. There is no intent to add structural value to the ballast section associated with the use of ATPLC. The intent is to incorporate a minimum quantity of asphalt while maintaining 6 microns of film thickness of asphalt regardless of the consequential high void percentage. ATPLC is generally recommended for use with rigid pavements. ATPLC is not necessary if ATB or Aggregate Base are used.

Aggregate Base: Previously discussed under Flexible reconstruction. Aggregate Base is not generally recommended with rigid reconstruction as drainage is an important consideration and crushed aggregate base is not generally considered conducive to drainage.

Rock Cap: Enter rock cap thickness as determined by the methods described in the Materials Manual. Rock Cap is generally recommended for rigid reconstruction. An Asphalt Treated Plantmix Leveling Course (ATPLC) is required for use with this item to fill in the surface voids and provide a smooth paving surface. The leveling course should not be included in the Granular Equivalent thickness of the section.

Granular Subbase: Granular Subbase is generally not recommended for rigid reconstruction unless a drainage layer of ATPB or Rock Cap is placed on top of it (see above).

Granular Borrow: Not currently recommended as a pavement section item unless otherwise approved. Current specifications for this material do not provide controls necessary to ensure a quality product.

The remaining input data for the Rigid Pavement Worksheet is identical to that which is described in the corresponding sections in the chapter on the Flexible Pavement Reconstruction Worksheet. Two additional comment are appropriate:

1) **Edge Drains** are generally recommended as a component of the positive drainage design for all rigid pavements.

2) **Subgrade Separation Fabric**, if toggled, is not calculated into the costs on this alternate. See discussion of this item in the Flexible Reconstruction chapter.

RIGID PAVEMENT ANALYSIS SHEET

This is a calculation sheet for determining the costs for various items considering widths, thicknesses, etc. As with the Flexible Pavement Analysis Sheet, values are read from the worksheet and the Standard Costs sheet and costs are calculated as appropriate. The calculated values are also read by the other sheets as appropriate. The costs shown with borders represent results which are used in the following Rigid Pavement Reconstruction Timeline sheet. The analysis sheet also contains the Introduction, Toggle Metric, Print Page, and Dialog Box command icons as previously described.

This is the sheet on which the "meat" of the work is done for the Life Cycle Cost Analysis program for this alternate. It is not generally felt to be necessary to include this sheet with LCCA reports as the relevant information is contained on other sheets in a more readable format. However, many report authors do include this sheet in the Appendix with the other sheets for reference purposes.

This sheet essentially functions the same as previously discussed in the corresponding section on Flexible Reconstruction.

RIGID RECONSTRUCTION TIMELINE

This sheet essentially functions identically to the corresponding sheet with respect to Flexible Reconstruction.

Due to the high cost and substantial disturbance to traffic associated with rigid reconstruction, a 40 year design life is generally considered appropriate for this alternate. The appropriate salvage value should be selected from the Salvage Value Chart and incorporated into the calculations for this alternate. Refer to the chapter on the Salvage Value Chart for further information.

Refer to the section on Flexible Reconstruction Summary for additional information.

RIGID RECONSTRUCTION SUMMARY

This sheet summarizes the calculations of the previously described sheets with respect to Rigid Pavement Reconstruction. As with the other sheets, a heading is shown which includes the date, project information, and designation of the alternative being considered. Following this is a short one sentence description of the initial construction included in the alternate including widths, thicknesses, and slopes.

The summary shows costs per kilometer (metric) or per mile (English). Summarized are costs for initial construction, subsequent sealing, 9 year rehab, 18 year rehab, and 27 year rehab. Emphasis is given to various items distinguishing this alternate from others. Following this information is listed the Total 36 year cost, EUAC, and Net Present Worth from the Timeline sheet. The Summary sheet provides simple concise identification of the characteristics of the alternate.

This sheet essentially functions the same as the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for further information.

Chapter

6

Widen and Overlay

The programming for this alternate is similar to that for the Flexible Reconstruction alternate. For descriptions of input data and calculations of this alternate which are not described in this chapter, the reader is referred to the chapter on Flexible Reconstruction.

WIDEN AND OVERLAY WORKSHEET

Generally speaking, this worksheet functions similarly to the other worksheets in the other worksheets in the program. The program assumes pavement items are to be placed full width and base and subbase items are to be placed to provide for widening only.

Widen Width – Left & Right Sides

Surface widths to be widened should be entered here. An overlay without widening may be evaluated by entering zero for the widths to be added.

Excavation for Widening

Estimated depth of excavation should be entered here. A check box is used to prompt the program to estimate a quantity for this item. The quantity estimated includes the width to be added and shoulders.

Subgrade Separation Fabric Layer

The user will note that if this item is toggled, the program calculates a full width subgrade separation fabric layer. Obviously, this is not constructible. As discussed in the Flexible Reconstruction chapter, the program calculates this item as a pavement membrane and is not recommended for LCCA purposes at this time regardless if the user intends to incorporate one into the project.

WIDEN AND OVERLAY ANALYSIS SHEET

This sheet essentially functions the same as previously discussed in the corresponding section on Flexible Reconstruction.

WIDEN AND OVERLAY TIMELINE

This sheet essentially functions identically to the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for additional information.

WIDEN AND OVERLAY SUMMARY

This sheet essentially functions the same as the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for further information.

Chapter

7

Inlay / Overlay Existing Pavement

The programming for this alternate is similar to that for the Flexible Reconstruction alternate. For descriptions of input data and calculations of this alternate which are not described in this chapter, the reader is referred to the chapter on Flexible Reconstruction.

INLAY / OVERLAY WORKSHEET

This sheet essentially functions as previously described in the chapters on Flexible Reconstruction and Widen / Overlay with the following exceptions.

It is assumed that no significant quantities of excavation are associated with this Alternate.

This alternate allows the user to accommodate a salvage value for rotomilled material which may be sold either to the contractor doing the work or another agency. In order to do this, an estimated salvage value must be entered in the appropriate cell in the **Depth** column. Then the check box for **Recycle** must be activated, showing "**Yes**" in the **Recycle** row / **Depth** column. This is read and calculated into the economic analysis in the Analysis sheet.

Often times a user will toggle the **Recycle** check box to state that material will be recycled if the material is to be given to another agency. However, if zero or no value is entered in the cell for the **Estimated Salvage Value**, no economic benefit is calculated. This is not considered inappropriate.

The program calculations assume that the full width of the roadway is to be rotomilled and inlaid in the project being analyzed even though the typical drawing shows only the travel lanes. As previously stated, the typical section drawing is for aesthetic purposes only and is not used in any calculations. Future rehabilitation is assumed to include rotomilling and inlaying full width.

INLAY / OVERLAY ANALYSIS SHEET

This sheet essentially functions the same as previously discussed in the corresponding section on Flexible Reconstruction, except as described above.

INLAY / OVERLAY TIMELINE

This sheet essentially functions identically to the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for additional information. Full reconstruction for this alternate is assumed to be necessary at 24 years. A 12 year salvage value for a 20 year design is assumed.

INLAY / OVERLAY SUMMARY

This sheet essentially functions the same as the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for further information.

Chapter 8

In Place Recycle Existing Pavement

This alternate evaluates recycling of existing pavement using the Hot In Place (HIP), Hot In Place with added virgin material, or Cold In Place Recycle (CIR) strategies. Only one strategy can be analyzed per "run". If it is desired to compare these strategies as different alternates, such comparisons must be made using separate electronic files.

Although the following does not specifically apply to the Life Cycle Cost Analysis spreadsheet, it is not inappropriate to discuss some of the issues concerning recycling here.

The HIP and HIP with virgin materials strategies should be supported with test information on the project showing consistent materials throughout. To date, ITD has had no HIP Recycle projects which have provided the anticipated life. HIP Recycle is nonetheless considered a viable option for consideration as it has been found to be successful elsewhere. Generally, the maximum depth for HIP Recycle is considered to be 1.5 inches. However, the HIP Recycle Repaving process allows HIP recycling up to a depth of 2.0 inches.

If CIR is chosen, 1.5% hydrated lime and 1.5 to 3.4 liters per square meter (0.5 to 2.5% by weight of pulverized material) of CMS-2S emulsified asphalt is generally added as this has been found to provide an adequate product under normal circumstances. Modifications to such these anticipated quantities / additives should be supported with appropriate test results / mix design. CIR still considered somewhat experimental for ITD projects and is considered a viable option on low volume roadways only. The maximum depth for CIR is 4 inches, with as much as 5 inches being considered marginal. Cold recycling depths have been reported up to 7 inches by making more than one pass of the recycling train; however, ITD has no experience with CIR at such depths. At least 1" of existing pavement must be left in place to provide a construction platform for the equipment. CIR should be followed by placement of a wearing course. Cover coat seals have been used for this purpose; other options include a double cover coat seal or a plantmix seal. However, a plantmix overlay of at least the minimum thickness required by the Materials Manual is generally recommended. If necessary to maintain the grade, material can be removed, although the LCCA program includes no salvage value for this.

CIR can be described as being an appropriate strategy for a project of which the conditions require more aggressive measures than are incorporated in a plantmix overlay or HIP Recycle, but the extensive reclamation procedures described in the following chapter on CRABS Reconstruction may not be warranted. One advantage of CIR over CRABS may be that CIR, if properly designed and constructed, should not break completely through the existing pavement. Therefore, if the underlying materials include excessive moisture, clays, or other deleterious materials, there is less chance of contamination as there is with CRABS.

RECYCLE PAVEMENT WORKSHEET

This worksheet functions similarly to that for previously described flexible pavement alternates; it is assumed that there are no significant quantities of excavation associated with this Alternate. Depths can be entered for all 3 options with this alternate; the choice of which strategy to use is governed by the use of check boxes as in the Inlay / Overlay alternate.

(Rotomill)

In the depth column, as with the Inlay / Overlay and Flexible Reconstruction alternates, this entry addresses rotomill depths for future rehabilitation and is not associated with the initial construction being evaluated.

Hot / Cold In Place Recycle

This check box toggles between Hot and Cold In Place Recycle. "Hot" or "Cold" will appear in the **Depth** column.

Additional Virgin Material

This check box toggles between "Do" Additional Virgin Material and "No" Additional Virgin Material. This option applies to Hot In Place Recycle only. At this time, '"No' Additional Virgin Material" should be toggled. Due to an bug in the program, toggling "'Do' Additional Virgin Material" incorporates the price of the additional material only instead of adding the price of Hot In Place Recycle plus additional virgin material. This discrepancy will be corrected in a future version of the program.

Cold In Place Recycle will calculate the same regardless of how this checkbox is toggled. For clarification, it is usually toggled "No" when Cold In Place Recycle is being evaluated.

RECYCLE PAVEMENT ANALYSIS SHEET

This sheet essentially functions the same as previously discussed in the corresponding section on Flexible Reconstruction, except as described above.

The Standard Costs sheet shows prices for Cold In Place Recycle in volume units even though it is labeled in area units. This label will be corrected in a future revision of the program. The actual pay unit in the standard insert for CIR is by area (m^2 or SY).

The program also uses volumetric pricing for Hot In Place Recycling even though this process is normally paid for on an area basis.

The Standard Costs for both Cold In Place Recycle and Hot In Place Recycle have been reviewed and are considered reasonable for Life Cycle Cost Analysis purposes at this time.

RECYCLE PAVEMENT TIMELINE

This sheet essentially functions identically to the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for additional information. Zero salvage value at 36 years for a 20 year design with future rehabilitation is assumed.

RECYCLE PAVEMENT SUMMARY

This sheet essentially functions the same as the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for further information.

Chapter

9

CRABS Reconstruction

The acronym CRABS stands for Cement Recycled Asphalt Base Stabilization. CRABS is a full depth reclamation process which converts existing flexible pavement into a base. First, the full thickness of the existing pavement is pulverized. The full thickness must be pulverized as the nature of the equipment requires this and construction of an impermeable layer in the base must be prevented. Cement is spread on the surface at a normal rate of 2% by weight of the pulverized material and mixed in order to stabilize the material. If additional strength is desired, a portion of the base may be incorporated into the mix if not contaminated by fines. Subbase materials are not considered appropriate for incorporation into a CRABS base as these materials are more granular than the equipment is designed for. A flexible overlay is then placed to provide a wearing course.

A CRABS base should not be confused with Cement Treated Base (CTB). The two types of materials are mutually exclusive. There is no intent to add strength to the pavement section associated with the addition of cement to the pulverized material. As previously stated, if additional strength in the base is desired, existing base materials should be incorporated into the CRABS base. Also, additional base material can be added if grade constraints permit. The sole purpose of the cement is to function as a binder for the fines and add stability to the CRABS base.

CRABS Reconstruction is so termed as the ballast section of the roadway is being reconstructed. In contrast to this statement, Inlay / Overlay is termed a rehabilitation in that the pavement is not reconstructed, it is rehabilitated. In all other respects, CRABS is a rehabilitation process. The user should not be anticipating a final CRABS project which is of the same high level of quality as would be expected from a Flexible or Rigid Reconstruction project. However, CRABS has been found to represent a high quality alternate without incurring the costs of full reconstruction.

There are several advantages of CRABS as opposed to other rehabilitation techniques. The flexibility of the roadway is increased. This is advantageous as thick asphaltic pavements have a tendency to act like rigid pavements with respect to freeze / thaw (i.e. thermal cracking) characteristics. Another advantage is that cracking, rutting, and roughness are addressed full depth. Other options, such as a plantmix overlay or rotomill and inlay address these problems only at the surface, and these problems have a tendency to return shortly after rehabilitation. It is felt that addressing these issues to the full depth of the pavement will delay the return of these problems as long as possible without full reconstruction.

CRABS RECONSTRUCTION PAVEMENT WORKSHEET

This worksheet functions similarly to that for the previously described flexible pavement alternate, including excavation. Normally, significant quantities of excavation would not be associated with CRABS. However, this feature is included as the CRABS process has the flexibility to allow excavating and replacing the ballast section using pulverized or CRABS processed material if such is required by the nature of the underlying materials.

This alternate allows the user to accommodate a salvage value for rotomilled material which may be sold either to the contractor doing the work or another agency. In order to do this, an estimated salvage value must be entered in the appropriate cell in the **Depth** column. Then the check box for **Recycle** must be activated, showing "**Yes**" in the **Recycle** row / **Depth** column. This is read and calculated into the economic analysis in the Analysis sheet. Often times a user will toggle the **Recycle** check box to state that material will be recycled if the material is to be given to another agency. However, if zero or no value is entered in the cell for the **Estimated Salvage Value**, no economic benefit is calculated. This is not considered inappropriate.

CRABS RECONSTRUCTION PAVEMENT ANALYSIS SHEET

This sheet essentially functions the same as previously discussed in the corresponding section on Flexible Reconstruction, except as described above.

CRABS RECONSTRUCTION TIMELINE

The CRABS alternate assumes a minor rehabilitation at 12 years and full reconstruction at 24 years. A salvage value at 36 years is incorporated.

CRABS RECONSTRUCTION SUMMARY

This sheet essentially functions the same as the corresponding sheet with respect to Flexible Reconstruction. Refer to the section on Flexible Reconstruction Summary for further information.

Chapter

10

Salvage Value Chart and Standard Costs Sheet

Rehabilitation: Background

Both the Flexible and Rigid Reconstruction alternates assume a 20 year design; rehabilitations are shown for flexible pavement at 12 and 24 years and at 18 years for rigid pavement. The purpose of these rehabilitations is to postpone reconstruction. It is assumed that further rehabilitations are not viable. As such, the Salvage Value zeroes out at 36 years. These alternates assume reconstruction at that time. This is the reason the Life Cycle Cost Analysis timelines are on a 36 year basis.

The Rehabilitation alternates in the Life Cycle Cost Analysis spreadsheet represent the rehabilitation strategies discussed above; i.e. any time a Rehabilitation alternate is being considered, said alternate is one of the rehabilitations shown on the Flexible Reconstruction timeline. As such, there are characteristics of the program which require scrutinization to determine if the alternate designs being considered are truly compatible.

The program makes the following assumptions with respect to rehabilitation alternates:

Widen and Overlay: Project being evaluated represents a 20 year design; a minor rehabilitation project at 12 years and a major rehabilitation at 24 years will allow reconstruct ion at 36 years

Inlay / Overlay: Project being evaluated represents a 20 year design; one more minor rehabilitation at 12 years is feasible; reconstruction required at 24 years

In Place Recycle: This option is generally considered an appropriate application on low volume/low priority roads which will not be reconstructed for 36 years due to lack of public demand; future minor rehabilitations are assumed at 12 and 24 years

CRABS: Project being evaluated represents a 20 year design. With one minor rehabilitation at 12 years, reconstruction will be necessary at 24 years.

The terms "minor" and "major" rehabilitation as used above are generalized and do not refer to specific ITD policies.

Obviously, the above assumptions do not apply to all projects. 8 and 10 year designs, which are allowed in the Materials and Design Manuals are not accommodated in the current version of the Life Cycle Cost Analysis spreadsheet. In order to evaluate projects for these design lives, the program must be tailored to the alternates and design life being evaluated. Generally speaking, this can be done by assuming reconstruction at the end of the design life being evaluated. From that point on, the sequence of events should follow that of the appropriate Reconstruction alternate. The appropriate salvage value at 36 years should be incorporated. This has been done in the past to evaluate such alternates as an 8 year inlay/overlay design, and an 8 year crack and seat vs. grinding. It is recommended that this be discussed with HQ Materials if it is the user's intent to do this.

The Salvage Value Chart is included with the workbook to allow the user to incorporate a dollar value into the analysis for any remaining life of the project at 36 years. This enables the user to evaluate the alternates on an equal basis with respect to project life.

Example: Rigid Pavement Grinding

Problem Statement:

Traffic analysis indicates an 8 year remaining life on a rigid pavement. Field inspection indicates no obvious base failure or drainage problems, and that the pavement can be rehabilitated by grinding.

Analysis:

The following example reflects an analysis of a theoretical ITD project. For the purposes of the example it is assumed that in the course of development of the Phase I and Life Cycle Cost Analysis that the grinding project would be followed by a crack and seat with a flexible overlay at the end of the current remaining life. As a crack and seat is considered a major rehabilitation, a future minor rehabilitation and reconstruction are assumed to fall within the 36 year timeline.

The following shows an example of what the Timeline sheet for such a project might look like. As the crack and seat procedure is a major rehabilitation, the maintenance schedule, after the design life, follows that of the Widen and Overlay alternate, with Flexible Reconstruction assumed at 24 years after the crack and seat.

Costs for grinding and slab removal and replacement for this example were taken from the Standard Costs sheet to determine the Initial Costs for the grinding project for Life Cycle Cost Analysis purposes.

The user will note that there is a cost shown for 2% slab removal and replacement in the Standard Costs sheet. In this example, it is assumed that it has been determined that 5 slabs out of a 10.5 mile project need to be replaced. Therefore the 2% standard cost is not used. Also, it is assumed that Rigid Reconstruction is not considered a viable option. Therefore, Standard Costs for Furnish Doweled Concrete are used. If this Alternate were being compared to a Rigid Reconstruction alternate (i.e. Furnish Concrete Pavement with a concrete paver), higher unit costs for concrete for slab replacement would be appropriate.)

ANALYSIS SHEET (for Initial Costs only):

			PROJECT NAME		Memory Lane		
Rigid Pavement Grinding / Repairs			PROJECT No.		**AB-1234(567)**		
8/19/98	10:28 AM		KEY		**9876**		
RIGID PAVEMENT QUANTITIES							
Analysis Section Length						55,677	ft
Traffic Cross Overs						$0.00	
Rotomilling						$0.00	
Additional Borrow						$0.00	
Additional Excavation				0	cu.yd	$0	
Percentage of Cracked Slabs (Rout and Seal)		**5**	**percent**				
Remove Concrete Slabs		**5**	**slabs**	**40**	**ft. long**		
	Width	24.00	ft				
	Depth	8.00	in				
	Unit Weight	156.07	lb / cu.ft				
				533	sq.yd		
	Cost	$2.68	$ / sq.yd			$1,427	
Furnish Doweled Concrete		5	slabs	40	ft. long		
	Width	24.00	ft				
	Depth	8.00	in				
	Unit Weight	156.07	lb / cu.ft				
				356	cu.yd		
	Cost	$44.20	$ / cu.yd			$15,700	
Place & Finish Doweled Concrete		5	slabs	40	ft. long		
	Width	24.00	ft				

	Depth	8.00	in				
	Unit Weight	156.07	lb / cu.ft				
				533	sq.yd		
	Cost	$16.50	$ / sq.yd			$8,800	
Additional Haul for Concrete Aggregates							
	Hauled	15.00	mile				
				11,237	t mile		
	Cost	$0.26	$ / t mile			$3,000	
Permeable (ATPB) Base Material		5	slabs	40	ft. long		
	Width	24.00	ft				
	Depth	4.00	in				
	Unit Weight	111.75	lb / cu.ft				
				89	t		
	Cost	$26.57	$ / t			$2,400	
Additional Haul for (ATPB) Base Material							
	Hauled	15.00	mile				
				1,341	t mile		
	Cost	$0.26	$ / t mile			$400	
Aggregate Base Material							
	Width	0.00	ft				
	Depth	0.00	in				
	Unit Weight	0.00	lb / cu.ft				
				0	t		
	Cost	$0.00	$ / t			$0	
Additional Haul for Aggregate Base							
	Hauled	0.00	mile				
				0	t mile		
	Cost	$0.26	$ / t mile			$0	
Grinding Full Width		55,677	ft				
	Width	34.00	ft				
				210,335	sq.yd		
	Cost	$4.55	$ / SQ.YD			$956,700	
Seal Longitudinal Joint (Conc to Conc.)		55,677	ft				
	Number of Joints	1					
				55,677	lin.ft		
	Cost	$1.75	$ / lin.ft			$97,400	
Seal Longitudinal Joints		55,677	ft				

(Asphalt to Conc.)							
	Number of Joints	2					
				111,354	lin.ft		
	Cost	$1.00	$ / lin.ft			$111,300	
Seal Transverse Joints		55,677	ft				
	Width	24.00	ft				
	Joint Spacing	40	ft				
	Number of Joints	1392		33,406	lin.ft		
	Cost	$1.75	$ / lin.ft			$58,400	
Rout and Seal Random Cracking							
	Slab Length	40.00	ft				
	Number of Slabs	1,392					
	Percentage of Slabs Cracked	5	percent				
	Number of Cracked Slabs	70		2,784	lin.ft		
	Cost	$1.75	$ / lin.ft			$4,870	
				Total Initial Cost		**$1,260,397**	
				Cost per Mile		$119,527	

Timeline:

Costs for a future crack and seat with a flexible overlay are determined using the same methodology as described above.

LIFE CYCLE COST ANALYSIS			STANDARD TIME LINES		19-Aug-98
PROJECT NAME	**Memory Lane**		36 YEAR LIFE CYCLE		
PROJECT NUMBER	**AB-1234(567)**		UNIFORM PROJECT COSTS PER MILE		
KEY	**9876**		(English units)		
	Rigid Pavement Grinding and Repairs				

YEAR		WORK	COST	PRESENT WORTH FACTOR	CAPITAL RECOVERY FACTOR	EQUIVALENT UNIFORM ANNUAL COST
0	---->	Initial Cost	$119,527	1.0000	0.0529	$6,300
-						
-						
-						
-						
5						
-						

-						
-						
-	---->	Crack and Seat/Overlay	$187,200	0.7026	0.0529	$7,000
10						
-						
-						
-						
-						
15						
-						
-	---->	Seal coat driving lanes	$20,200	0.5134	0.0529	$500
-						
-						
20						
-	---->	Rehab Seal Cracks	$102,500	0.4388	0.0529	$2,400
-						
-						
-	---->	Seal cracks	$35,400	0.3901	0.0529	$700
25						
-						
-	---->	Seal Cracks	$35,400	0.3468	0.0529	$600
-	---->	Seal coat driving lanes	$20,200	0.3335	0.0529	$400
-						
30	---->	Seal Cracks	$35,400	0.3083	0.0529	$600
-						
-						
-	---->	24 Year Reconst Cost	$328,600	0.2741	0.0529	$4,800
-						
35						
-	---->	End Life - Salvage Value	($318,742)	0.2444	0.0529	($4,100)
		TOTAL	$565,685		EUAC ----->	$19,200
				Total Net Present Worth @ 4%		$363,000

This alternate can then be compared to other alternates for the example project. A decision for a selected alternate can be made with respect to economics and engineering feasibility.

Additional Comments:

The dollar values from the Timeline should not necessarily be taken as representative as the following information was compiled from data sheets from different alternates and projects, and roadway widths are not necessarily consistent for different applications in the schedule. However, the sequence of events is reasonable and the purpose of this example is to show the use of the Salvage Value chart and Standard Costs sheet.

For this theoretical example, it is assumed the salvage values shown in the chart will be realized in the form of lower maintenance costs. Therefore, the salvage value can be deducted from the Total 36 Year Life Cycle Cost and the Total Net Present Worth. A new EUAC can be calculated by dividing the Capital Recovery Factor out of the Total Net Present Worth.

Conclusions:

Generally speaking, a 20 year design life is recommended for all projects. Current policies allow for as little as an 8 year design life; any less than a 20 year design life must be justified. The Life Cycle Cost Analysis program is a tool which may be used to provide such justification with proper input data. Considering the real-life issues of remaining design life, existing roadway conditions, project funding, and program budgeting, it may be more appropriate in some cases to reduce the construction ballast section and realize such benefits in the form of reduced initial construction costs.

The purpose of the Standard Costs Sheet is to provide an "apples to apples" comparison for various Alternates. The unit prices shown on the sheet are not necessarily reflective of actual costs. The unit prices on the Standard Costs Sheet should not be changed as the values would then be incorrect relative to one another, and the analysis would be considered invalid.

The user may note that the above values for Flex Reconstruction with the Salvage Value do not include an additional item for scarifying the existing pavement. This cost is nearly negligible compared to the total.

Recommendations:

Use of the Salvage Value Chart for consideration with respect to flexible and rigid Reconstruction is recommended where appropriate.

One possible interpretation of the above example is that CRABS can be used as a future rehabilitation / reconstruction strategy. However, this alternate is a relatively new innovation. The current design procedure for CRABS is speculative as the determination of the design life has not been confirmed in the field. It is currently undetermined whether CRABS should be considered a reconstruction or a rehabilitation. Therefore, the above described methodology is not recommended for the CRABS alternate at this time. However, it is possible that it may be considered in the future at such time as the design procedures are confirmed. Also, the In-Place Recycle and Inlay/Overlay alternates are rehabilitation strategies. The above methodology is not recommended for use with the In-Place Recycle and Inlay/Overlay alternates. Deviation from the maintenance schedules shown in the timelines for the various alternates should not be made without discussion with H.Q. Materials.

Chapter

11

Closing

In summation, Life Cycle Cost Analysis aids the engineer in developing a recommendation for a design alternatives for a given project. It is intended to lend economic and engineering support to the selection of an alternate. It does not necessarily account for all of the engineering requirements which may be necessary and is a subjective analysis method. The costs calculated in the program are not necessarily indicative of actual project costs. Deviations from the maintenance schedules shown in the timelines of the various alternates are not recommended unless the issues are previously discussed with H.Q. Materials. The purpose of the LCCA is to determine the economic feasibility of one paving / construction alternative to another. Comparing the cost results of the LCCA spreadsheet to those generated by an engineering estimate can be said to be an "apples to oranges" comparison.

It is hoped that this guide will be of assistance in using the spreadsheet and in the selection of alternatives in the project development process. For assistance or comments concerning various issues relating to this guide or on how this information relates to specific projects, please contact the ITD HQ Materials Project Development Engineer or the Assistant Materials / Research Engineer at the address or phone number at the beginning of this guide.

References:

Life Cycle Cost Analysis program version 11-98

Pavement Recycling Guidelines for State and Local Governments FHWA-SA-97 published December 1997.

Asphalt Recycling and Reclaiming Association Technical Disciplines published March 1990.

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